Toward cheaper imaging systems for identifying concealed weapons on the human body

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Electrical engineers from UC San Diego have created high-performance W-Band silicon-germanium (SiGe) radio frequency integrated circuits (RFICs) for passive millimeter-wave imaging. This advance could lead to significantly less expensive imaging systems for identifying concealed weapons, for helping helicopters to land during dust storms, and for high frequency data communications.

The new millimeter wave amplifier system works at the same frequency and follows the same underlying principles as some of the most advanced security imaging systems now in use in airports. The new UC San Diego circuit is unique in that it uses standard silicon semiconductor technology, while today's security imaging systems working in the same millimeter frequency range often rely on expensive gallium arsenide or indium phosphide amplifiers. This advance is from the laboratories of Gabriel Rebeiz, a professor of electrical engineering at UC San Diego's Jacobs School of Engineering and a world leader in millimeter-wave RFIC design, phased-arrays and Micro-electro-mechanical systems (MEMS).

The RFIC Conference is the premiere annual conference in the world for reporting recent research developments in Radio Frequency Integrated Circuits (RFICs). These circuits are responsible for the communications links in all wireless devices. This year, UC San Diego has 11 (out of 140) papers at the conference, which is much more than

any other university.

"Our circuit functions at the same frequencies as some of the most advanced millimeter wave imagers around. The big difference is that we are using a commercial silicon semiconductor process technology while other systems are typically customized and very expensive. The technologies that we use are very inexpensive and reliable, so we should be able to bring the costs of those sorts of systems down, perhaps even to handheld scanners some day," said Jason May, an electrical engineering PhD student at UC San Diego's Jacobs School of Engineering and the first author on the RFIC 2009 paper.

The new circuit also includes an antenna that can be used to capture radiation in the millimeter wave frequency emitted from the human body and from objects under a person's clothing. This radiation passes through clothing largely or completely unaffected.

Imagers operating at millimeter waves are particularly useful because they can resolve images down to a millimeter scale, fine enough detail to identify small objects and separate items on a person's body.

"By the size of the signal we detect, we can tell the temperature of the signal we are looking at," explained Gabriel Rebeiz, the electrical engineering professor at UC San Diego's Jacobs School of Engineering supervising the project. "An imager with our chip could resolve images down to a millimeter scale, enabling us to identify very small objects that are on someone's body," said Rebiez.

"A ceramic knife concealed against a person's leg, for instance, might appear one or half of one degree cooler than the rest of their body. We could then tell that something is there and we could exactly determine its shape," said May.

Using signal processing, these kinds of scanners can put together an image of a temperature map of a person's body that includes any objects underneath the clothing.

Imagers, high speed communications systems, and other applications that operate at the millimeter wave frequency are poised to become increasingly prevalent and influential as the circuit technologies for integrating them with existing silicon technologies matures.

"Our success at this conference is a direct result of the investment that UC San Diego has made over many decades in the field of wireless communications. The RFIC field requires an interdisciplinary team, because it requires innovation in the areas of electronic devices, integrated circuit theory, electromagnetic theory and communications systems. The broad skills of the UCSD faculty have made this extraordinary level of research innovation possible," said Larry Larson, Professor and Chair, Department of Electrical and Computer Engineering at the UC San Diego Jacobs School of Engineering.

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